

Issued February 3, 1915.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF SOILS—MILTON WHITNEY, Chief.

SOIL SURVEY OF GOODHUE COUNTY,
MINNESOTA.

BY

WILLIAM G. SMITH, H. L. WESTOVER, B. D. GILBERT,
AND N. M. KIRK.

[Advance Sheets—Field Operations of the Bureau of Soils, 1913.]



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1915.

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LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., June 9, 1914.

SIR: In the extension of the soil survey in the State of Minnesota work was undertaken in Goodhue County during the field season of 1913.

The accompanying report and map cover this survey, and are submitted for publication as advance sheets of Field Operations of the Bureau of Soils for 1913, as authorized by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

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MAP.

Soil map, Goodhue County sheet, Minnesota.

SOIL SURVEY OF GOODHUE COUNTY, MINNESOTA.

By WILLIAM G. SMITH, H. L. WESTOVER, B. D. GILBERT, and
N. M. KIRK.

DESCRIPTION OF THE AREA.

Goodhue County is situated about 40 miles southeast of St. Paul, the State capital, in the southeastern part of the State. It is bounded on the southeast and south by Wabasha, Olmsted, and Dodge Counties, on the west and northwest by Rice and Dakota Counties, and on the northeast by the Mississippi River, the main channel of which is also the State line between Minnesota and Wisconsin.

Goodhue County is about 34 miles wide from north to south and 38 miles long from east to west, and the area included is 767 square miles, or 490,880 acres. The county consists of a rolling to moderately level upland, having an elevation above sea level of about 1,000 feet in

the eastern part of the county, with a gradual rise westward to nearly 1,200 feet. The northern and northeastern parts of the county are relatively rough and hilly, owing to the presence of many steep-sided valleys, which here have been cut to depths of 50 to 300 feet or more below the general level of the upland. This more hilly portion lies contiguous to the Cannon and Mississippi River

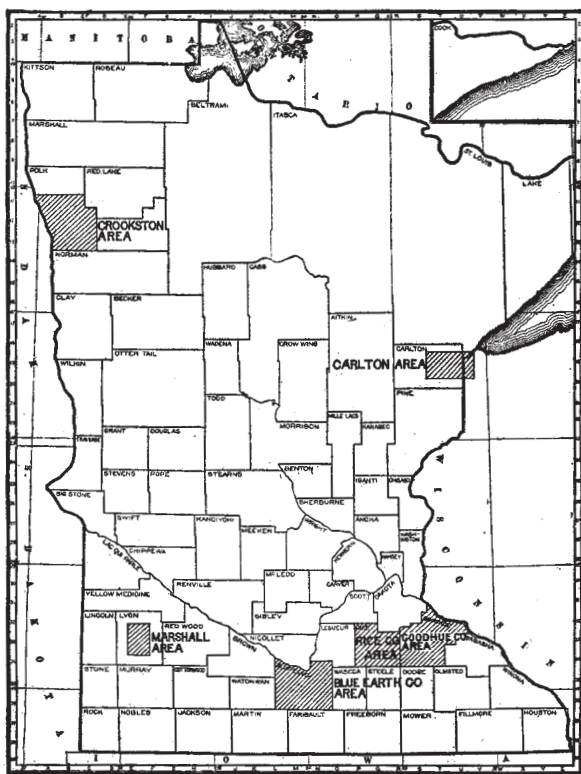


FIG. 1.—Sketch map showing areas surveyed in Minnesota.

Valleys, and the less hilly portion lies in the southern part of the county.

The deeper valley slopes are as a rule marked by steep, rocky bluffs, from one-fourth mile to 2 miles apart, presenting a more or less broken outline. The large valleys include river terraces, from 30 to 100 feet above the mean stream level, and the recent alluvial floors between the terraces lie from 5 to 15 feet above the streams. The terraces range in width from less than one-eighth mile to about $1\frac{1}{2}$ miles and the overflow bottoms from less than one-eighth mile to nearly a mile. Terraces are not usually found along the minor streams.

The regional drainage of the county is eastward toward the Mississippi River, largely through the Cannon River, flowing in a winding course through the northern part of the county, and the North Fork of Zumbro River, which drains the southern part.

Goodhue County was organized in 1853 by an act of the Minnesota Territorial Legislature, but the boundaries were not definitely determined until 1854, or after the completion of the United States land surveys. Some settlement had preceded the organization of the county; soon thereafter it became more rapid. Townsites were early laid out, Red Wing, the county seat and the largest city in the area, with a present population of 9,048, being among the first. Cannon Falls, with a population of 1,385; Kenyon, with 1,237; Zumbrota, with 1,138; and Pine Island, with 834, are some of the other larger towns. There are about 30 smaller towns scattered over the county. The population of the county, according to the last census, is 31,637, of which a considerable proportion is rural. The density of population is about 40 persons per square mile.

A large proportion of the population is of Scandinavian, Irish, and German origin. The Scandinavians are said to predominate in the western half of the county. More Irish are found in the central part and more Germans in the eastern part.

Goodhue County is well provided with railway transportation facilities, three different systems entering the county. All of the larger towns and many of the smaller ones are located on railroads, and no part of the county is more than 10 miles from a shipping point. The larger commercial centers, such as St. Paul, Minneapolis, Omaha, Kansas City, and Chicago, are readily accessible.

The Mississippi River is navigable from St. Paul to St. Louis and beyond during most summers. Considerable freight and passenger traffic is handled by shallow-draft river steamers during the summer and fall when the stage of the river permits.

The county roads are as a rule in fair condition for travel. Many of the roads of the southern three-fourths of the county are located on section lines, the surface of the county being relatively less hilly. In

the northern and northeastern portions of the county the roads are more crooked, for the reason that they follow lines of easier gradient within a more hilly topography.

CLIMATE.

The average annual temperature at Red Wing is 43.9° F. The coldest months are December, January, February, and March, when the mean temperature is below freezing, January showing the lowest average, 10.9° F. June, July, and August are the hottest months, July showing the highest average, or 72° F.

Some very high temperatures have been recorded during the growing season, the highest being 106° F. in July. The lowest temperature recorded is -31° F. in January.

The average date of the last killing frost in the spring at Red Wing is May 4 and of the first in the fall October 11. The Mississippi River probably exerts a modifying influence here, since similar data at St. Charles, which is farther removed, gives May 16 and September 27, respectively, as the average dates of last killing frost in spring and first in autumn, or an average period of 134 days during which no killing frosts occur as against 160 days at Red Wing.

Following the first killing frost in the fall there are very warm days, with cool, frosty nights, sometimes extending over a period of several weeks, during which fall-seeded rye makes good growth. Some of the summer pasture crops, such as rape, afford grazing until late in the fall.

The mean annual precipitation at Red Wing is 29.99 inches and at Zumbrota 24.89 inches. About two-thirds of the precipitation occurs during the crop-growing months, April to September, inclusive. The total amount for the driest year shown at Red Wing is 18.98 inches and for the wettest year 38.74 inches, an extreme variation of 19.76 inches. As a rule, however, the rainfall is sufficient and so distributed as to insure crop production, especially where proper cultural methods are used. The precipitation in May and June is usually well distributed and drought periods are rare. In July the distribution is not quite so good and grain in the "dough" stage may be injured, especially if the prevailing southwest wind happens to blow strong and hot. On the average rain falls about every third or fourth day during the three months of May, June, and July.

The average annual snowfall at Red Wing is 28.9 inches and at St. Charles 42.9 inches. Snow falls from October to May, inclusive, the greater amount falling from December to March, inclusive. The average depth at Red Wing is 7.1 inches for December, 8 inches for January, 5.6 inches for February, and 4.4 inches for March. During the coldest winter months the snow cover is fairly constant, giving good protection for grasses and other low-growing vegetation.

Occasionally rather open winters, with alternate freezing and thawing, occur, resulting in much injury to vegetation.

The sky is relatively free from clouds. There are on an average 175 to 185 clear days and 82 to 86 cloudy days, the rest of the year being partly cloudy. The longer period of sunlight of this latitude in summer (14 to 16 hours) probably offsets in a measure the disadvantage of a rather short period between dates of killing frosts, the crops maturing more rapidly here than in the lower latitudes.

The following table gives the salient facts concerning the climate of Goodhue County:

Normal monthly, seasonal, and annual temperature and precipitation at Red Wing.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	° F.	° F.	° F.	Inches.	Inches.	Inches.	Inches.
December.....	20.1	54	-25	1.19	1.94	1.56	7.1
January.....	10.9	46	-31	1.22	0.80	0.46	8.0
February.....	14.9	51	-30	1.13	0.54	0.69	5.6
Winter.....	15.3			3.54	3.28	2.71	20.7
March.....	27.3	68	-17	1.39	0.51	0.90	4.4
April.....	45.9	89	17	2.27	1.35	2.36	1.8
May.....	55.9	92	25	3.64	1.85	6.75	0.2
Spring.....	43.0			7.30	3.71	10.01	6.4
June.....	68.0	99	38	4.34	3.01	2.29	0.0
July.....	72.0	106	46	3.44	2.23	8.72	0.0
August.....	68.6	95	40	3.72	3.96	4.36	0.0
Summer.....	69.5			11.50	9.20	15.37	0.0
September.....	61.1	95	28	3.80	1.45	4.01	T.
October.....	48.7	85	16	2.57	0.02	2.62	0.3
November.....	33.3	78	- 8	1.28	1.32	4.02	1.5
Fall.....	47.7			7.65	2.79	10.65	1.8
Year.....	43.9	106	-31	29.99	18.98	38.74	28.9

AGRICULTURE.

Local county histories indicate that the early settlers sought out the valley lands first, timber and readily available water probably being an attraction. Later the uplands were settled and developed into farms, the question of water supply being solved by the deep dug wells first, and later by the modern deep well borings, with windmill and gas-engine power lift.

One of the early settlers of Featherstone Township in 1856 brought with him from Canada a few bushels of Fife wheat, and during the

first few years he sold his crops of this wheat for seed. It is said that this was the origin of the hard spring wheat of Minnesota. The bluestem wheat, a soft spring wheat, was later introduced, and by 1885 was extensively grown in the county, and now is almost exclusively grown.

The small flint corns were among the early crops grown, though not so extensively as wheat. It was not until about 1870 that corn assumed importance, or after the introduction of strains of dent corn that would mature within the relatively short growing period of this section.

In the early years of settlement wheat was almost the only money crop grown in the county. At first the yields ran high, but owing to the system of continuous cropping on the same land and to the ravages of the chinch bug, they later declined to a point where they barely paid the expenses of growing the crop. As a result some farmers began to grow barley, and as excellent results were secured this took the place of wheat for some time. After several years of continuous cropping the yields of this crop also began to decrease and it became apparent that some sort of rotation of crops was necessary. This led to the growing of oats, barley, and grass in succession.

The leading crops in the county at present are corn, oats, flax, hay, wheat, barley, and rye.

For several years wheat was very little grown, but in the last few years this crop has been taken up again and at present a considerable acreage is annually devoted to it, although much less than formerly. Fairly good yields are obtained.

By far the greater percentage of land in this crop is in spring wheat, though some small areas are in winter wheat. Better results are usually obtained with spring wheat, as the winter varieties are apt to winterkill. The yields range all the way from 10 to 25 bushels, with an average of 15 to 18 bushels per acre. These differences are caused mainly by different methods of cultivation and by variations in the amount of rainfall.

It was at first thought that the growing season was not long enough for corn, but this crop has been tried in recent years, and with very good success, although it is necessary to plant early maturing varieties. It is grown in nearly all parts of the county, but more extensively in the stream valleys than on the uplands. At first the crop was allowed to mature, but now the greater acreage is cut green and used for filling silos.

Oats are grown in all parts of the county. So far as possible the plowing is done in the fall and the ground loosened again in the spring with a disk harrow. The yields of oats run from 40 to 60 bushels per acre. Occasionally the yields run somewhat higher over

small tracts. Where the land has been enriched with stable manure the straw grows so rank that it is apt to lodge and the loss resulting in this way is frequently heavy. In some years there is also considerable loss from rust. The harvesting is done with a binder, and after drying in shocks the oats are stacked and thrashed later in the fall. A few farmers, however, thrash directly from the shock. It is said that the stream valleys are somewhat better adapted to oats than the uplands. There is very little difference in the yields secured.

Next to oats, barley is probably grown to a larger extent than any other grain crop. The yields range from 30 to 45 bushels per acre. Much of the straw is burned in the fall after thrashing. Some of it, however, is saved for cattle to feed on during the winter or for use as bedding.

Rye is grown to quite an extent in all parts of the county. As a rule winter varieties are grown, though some small fields are in spring rye. The yields range all the way from 20 to 30 bushels per acre, depending on the season and treatment. This is usually the first grain crop to be harvested and much of the thrashing is done from the shock. Some of the straw is saved for bedding, but by far the greater part of it is burned immediately after thrashing.

Hay, both clover and timothy, is grown rather extensively. In a favorable season clover yields from $1\frac{1}{2}$ to 2 tons and timothy 1 to $1\frac{1}{2}$ tons per acre. Two crops of clover are obtained in some seasons. When the weather conditions are such that the second crop is not too rank it is occasionally left for seed. Some timothy is harvested for seed when conditions are favorable.

Flax is grown to some extent in various parts of the county, but more particularly in the southwestern part, where there is considerable low and rather poorly drained land. It is produced for grain, and no use is made of the straw, most of it being burned. The yield runs from 8 to 15 bushels, with an average of 12 bushels per acre. This crop is seldom grown on the same land for more than one year. Mixtures of flax and wheat, flax and oats, or flax and barley are also sowed. It is said that larger yields are obtained where the two crops are grown together.

Other crops grown to a limited extent are strawberries, apples, milo, millet, buckwheat, potatoes, and sugar beets.

While small fields of sugar beets are found in various parts of the county, by far the largest acreage is grown in the southeastern part in the vicinity of Mazeppa, which lies just over the line in Wabasha County. Very good results are obtained.

No large apple orchards are found in the county, but many of the farmers have a few trees and a few orchards of 5 or 6 acres exist. In favorable seasons good yields are obtained and the quality of the

fruit is fairly good. Late spring frosts often reduce the yield. With a few exceptions, very little care is given the orchards after they are planted. They are never sprayed and seldom pruned or cultivated.

Alfalfa is being tried in different sections and is apparently doing well. Some good fields are found southeast of Cannon Falls on the Sogn clay loam and also on the Waukesha silty clay loam west of Red Wing. The success of these trials would seem to justify the growing of this crop more extensively.

Sorghum is grown in several parts of the county. It is probable that the largest acreage is found in the vicinity of Cannon Falls, in the valleys of the Cannon and Little Cannon Rivers. The fields in this crop are usually small, seldom exceeding 1 or 2 acres. In some cases sorghum is cut for forage, but the greater part is used in making sirup. Very little of this, however, is made for sale, the greater part being used for home consumption.

Millet is also widely though not very extensively grown. This crop is used more in the western than in the eastern part of the county. It is cut for hay.

A few small fields of buckwheat were seen during the survey, but the acreage devoted to this crop is very small.

Nearly every farmer has a patch of potatoes large enough to supply the home needs. Usually the local production is sufficient to supply the demands of the county. No potatoes are exported, and it is sometimes necessary to ship them in.

Sweet corn is also grown to some extent and sold at the canning factories, of which there are three or four within the limits of the county.

During the past season several fields of peas were grown for canning near Pine Island. This is the first season this crop has been tried.

Other truck crops, such as onions, cabbage, tomatoes, lettuce, and radishes, are usually grown in the vicinity of each town to supply the local demand.

Wild plums and grapes are found in all parts of the county, and these are used quite extensively in making preserves.

It is the general practice in so far as possible to do the plowing in the fall. It is claimed that larger yields result in this way, and, besides, this makes it possible to get the crops in earlier, which is an important thing in this climate. Where it is not practicable to do the plowing in the fall, it is done as early in the spring as possible.

In early days no attention was paid to dairy farming, but as a result of the decreasing yields of grain crops this industry has gradually grown until in some of the rougher portions of the county it has become one of the leading sources of income to the farmer. This industry has made it possible to utilize areas of rough, broken land for pasturage which had previously lain idle. While there is

very little blooded stock, nearly every farmer has a few head of good grade cows. During the summer months they produce considerable milk, but in the majority of cases no attempt is made to keep up the production during the winter months. There are one or more cheese factories in practically every township, which operate during the summer months, when there is an abundance of milk. The majority of them, however, close down during the winter, when the milk production decreases. In addition, nearly every township has its creamery, and a large amount of butter is manufactured during the summer, but here, too, the production falls considerably during the winter. Some of these creameries are owned by the farmers and others by private concerns. Besides these two ways of disposing of the milk, many of the farmers along the lines of railroads having direct communication with St. Paul and Minneapolis ship milk to these cities.

There are no large poultry farms in the county, but each farmer keeps a few chickens, and large quantities of eggs are shipped to outside markets. Many farmers also keep a few turkeys and these also are shipped to outside markets, Chicago being the leading market.

Some hogs are raised, but the industry is not as yet very extensive. The majority of the farmers raise a few for home use and have a small surplus for sale.

A few flocks of sheep are found in the county.

Excepting the small quantity of fertilizer used in truck growing, none is used in the county. Fertilization is restricted to the use of stable manure, the supply of which, except on the dairy farms, is inadequate. It is nearly always used on the corn crop or applied as a top dressing to grass. Where land is pastured for 2 or 3 years or more it receives considerable fertilizer in this way. At times, too, a second growth of clover is plowed under. This is usually done where corn is to be planted the following year. Stable manure is seldom applied to land that is to be seeded to grain, as it causes lodging.

The census of 1910 shows a total of 462,052 acres in farms in Goodhue County. Of this 220,441 acres is included in field crop acreage, the remainder being woodland, stony bluffs, overflow bottoms, and permanent pasture. There were 3,040 farms, with an average of 152 acres, an increase of 22 acres as compared with the size reported in 1880. Sixty-eight per cent of the farms were operated by the owners as compared with 73.8 per cent in 1900 and 78.68 per cent in 1890.

According to the census, the total value of all farm property in 1910, including land and improvements, buildings, implements and machinery, live stock, and field crops was \$34,920,997. The land was valued at \$21,041,642, or an average of \$45.54 per acre as against \$26.13 in 1900. The value of the land seems not to have varied much from 1880 to 1900, the greatest increase having taken place during the last 10 years. The value of the buildings was \$6,491,836, more than

double that shown by the 1900 census, and of implements and machinery \$1,120,114, which is nearly double that shown in 1900. Live stock was valued at \$3,613,070, or over \$1,500,000 more than in 1900, over \$2,000,000 more than in 1890, and about \$2,300,000 more than in 1880. Of the live-stock valuation the greater part, or \$2,064,651, was represented by horses, \$1,163,822 by cattle, \$216,252 by hogs, and \$168,360 by sheep, mules, and poultry.

The total value of the field crops amounts to \$2,654,334. In 1912¹ the 13 creameries of Goodhue County reported 2,288,066 pounds of butter made, for which \$569,930 was paid the patrons, and the 20 cheese factories reported 1,589,902 pounds made, for which \$208,700.26 was paid the patrons, the aggregate value of the dairy products amounting to \$778,630.26.

The greater part of the upland of Goodhue County is treeless. Most of the valley lands, however, have more or less forest, consisting of white elm, red elm, soft maple, box elder, white willow, black walnut, butternut, hard maple, hackberry, red willow, and white birch. In rare instances small areas of oak exist in the upland. The forest affords considerable material useful on farms, such as firewood, fence posts, and some lumber. Wild plum, cherry, raspberry, grape, gooseberry, and currant are also found on valley slopes and bottoms. The fruit from these is utilized. Willow, cottonwood, soft maple, box elder, and other trees have been planted about most of the farmhouses.

The following table gives statistics of the principal agricultural products of Goodhue County:

Acreage, production, yield per acre, and value of the principal crops of Goodhue County, based on census of 1910.

Crop.	Number of acres in field crops.	Per cent of field crop area.	Production.	Yield per acre.	Value per unit. ²	Total.
Barley.....	80,924	36.71	1,889,142 bushels..	23.3	\$0.44	\$831,223.00
Oats.....	49,044	22.25	1,678,348 bushels..	34.2	.31	520,288.00
Wheat.....	33,003	14.97	639,250 bushels....	19.3	.78	498,615.00
Corn.....	27,267	12.37	951,862 bushels....	34.9	.42	399,782.00
Rye.....	16,546	7.51	293,889 bushels....	17.7	.55	161,639.00
Wild grass.....	5,585	2.53	8,627 tons.....	1.5	5.00	43,135.00
Clover.....	2,988	1.37	6,591 tons.....	2.2	6.23	41,062.00
Forage crops sown.....	2,104	.96	7,807 tons.....	3.7	5.00	39,035.00
Potatoes.....	1,430	.65	165,728 bushels....	115.9	.40	66,291.00
Tame grasses.....	736	.33	1,299 tons.....	1.8	6.23	8,093.00
All vegetables except potatoes.....	644	.29	.....	.....	.....	.....
Grains cut for hay.....	108	.04	647 tons.....	6.0	6.23	4,031.00
Sorghum.....	33	.01	2,121 gallons.....	64.3	.40	848.00
Beans.....	26	.01	524 bushels.....	20.1	2.00	1,048.00
Peas.....	3	.....	17 bushels.....	.....	2.00	34.00
Orchard products.....	.....	.....	.....	.....	.....	39,210.00
Total.....	220,441	.....	.....	.....	.....	2,654,334.00

¹ Staté Dairy and Food Department, St. Paul, Minn.

² See p. 40, Minn. Bureau of Immigration report of Nov. 1, 1911, on market value of crops.

Of the 220,441 acres planted to field crops in 1909, 36.71 per cent was devoted to barley, and the acreage of barley, oats, wheat, and corn combined formed 86.3 per cent of the cultivated area.

No systematic rotation is followed in the county, though frequent change is made in the succession of crops. Corn is very frequently grown two years in succession on the same land. This may be followed by rye, oats, or barley for one or two years, when it is seeded down. More frequently oats or barley is followed by a crop of rye, the land then being seeded to clover and timothy and left for two or three years or sometimes much longer. It is claimed that a better stand of clover is secured from seeding with rye than with any other grain crop. As already stated, flax is seldom grown more than one and never more than two years on the same land. As a rule, the sod land is kept in pasture two or three years after it has been used for hay production. The large proportion of land in cereals—86.3 per cent, according to the census of 1910—indicates clearly that the rotation followed is not well balanced. A greater acreage should be given to the grasses.¹

Farm hands are paid from \$25 to \$35 a month, with board, making the total cost approximately \$50 a month. During short periods, such as at harvest time, they receive \$2 to \$3 a day with board. Farm laborers are scarce, especially when most needed, as at harvest time.

Improved farms in all parts of the county are held at \$75 to \$100 an acre. Where situated near towns and where the buildings and lands are in an unusually good condition values are frequently somewhat higher. Farms with run-down, hilly land and buildings out of repair and where there is considerable nonagricultural land included bring from \$40 to \$50 an acre.

SOILS.

The soils of Goodhue County may be grouped broadly into three divisions, (1) the upland division, consisting mainly of silt loam; (2) the high river terraces, and (3) the bottom lands, the two latter groups including material of much more varied texture than the true upland.

The materials from which the various soils are derived are varied. They include first a mantle of fine-textured unconsolidated material known as loess. This covers the eastern three-fourths of the upland of the county and has a depth varying from 1 foot to 15 feet. Where of light color the loess gives rise to the Knox silt loam; where the surface is darker, to the Marshall silt loam. These two types form the greater proportion of the loessial area, though a few scattering areas of Knox fine sandy loam are mapped.

¹ Bul. 125, Minn. Agr. Expt. Stat. P. 37. This bulletin gives much valuable information regarding the improvement of rotations for Minnesota.

Underlying the loessial deposit and exposed as upland in the remaining one-fourth of the county is a deposit known as the Kansan glacial drift. This drift deposit is considerably thinner in the eastern part of the county, varying from a few inches to about 40 feet, while in the western part it is 100 feet or more thick in many places.

The darker colored areas of exposed glacial drift give rise to extensive areas of Carrington loam and to many smaller areas of Carrington silty clay loam and Carrington fine sandy loam. The lighter colored exposures form the Miami silt loam and the Miami fine sandy loam.

South and west of Zumbrota is found a series of gravelly knolls and ridges, which are thought to be in part glacial drift and possibly in part kame deposits. The surface covering, as a rule, consists of 1 to 3 feet of a loesslike silt loam material, with some gravel, beneath which deep deposits of sand and gravel are found. Part of the substratum shows cross-bedding. The knoll areas are mapped as Miami silt loam, gravel hill phase.

Underlying the loessial and glacial deposits above referred to massive rock strata are found, consisting of alternate layers of limestone, shale, and sandstone. These strata have a slight dip westward, and are in most places deeply buried. They are exposed mainly in the northeastern part of the county, where deeper valleys have been carved out. Some weathered exposures of limestone are found south of Cannon Falls. These give rise to the Sogn clay loam.

The larger valleys, 50 to 300 feet deep, have been cut through several of the rock strata in the northern and northeastern parts of the county.

The hard rock strata exposed along these valleys stand out in bold, vertical cliffs, which with their talus, consisting of rock fragments mixed with varying amounts of fine-earth material, are indicated on the soil map as Rough stony land.

The St. Peter sandstone and St. Croix sandstone¹ are both soft and easily weather into a fine sandy material. The lower slopes of the larger valleys often show exposures of these sandstones as weathered outwash more or less mixed with material washed from the upland silt loams. Areas of this character are mapped in part as the Red Wing loamy sand and in part as Miami loamy sand.

It is presumed that the soft sandstone strata have contributed also to a greater or less degree in the formation of the loams and fine sandy loams found on the river terraces and lower bottoms of the valley lands.

High river terraces² are found along the Cannon, North Fork Zumbro, and Mississippi Rivers. These terraces, though relatively inextensive are, nevertheless, a very prominent feature of the valley land topography. They occupy two well-defined levels approximately

¹ Minn. Geol. and Nat. Hist. Survey, Vol. II, p. 20-61.

² Data supplied by Dr. Frank Léverett, of the U. S. Geological Survey.

40 and 90 feet above the present stream levels. Minor intermediate terraces are also more or less evident.

It is said that the larger preglacial valleys of the area were only partially filled by the glacial drift materials and that the glacial water during the recession of the Kansan glacial ice sheet flowed along these old drainage valleys, gradually filling them with a deposit varying from clay to gravel. These terrace deposits give rise to the Plainfield silt loam, Miami loamy sand, Waukesha fine sandy loam, Waukesha loamy sand, Waukesha gravelly sandy loam, Waukesha silty clay loam, and Waukesha loam. The first two types include light-colored soils, and the Waukesha series the dark-colored soils.

Since the streams have reached their present level they have deposited on their flood plains materials that have been mapped as the Wabash silt loam, Wabash loam, Wabash fine sandy loam, and Wabash gravelly sandy loam. These soils are all dark colored.

The following table gives the actual and relative extent of the several soils of Goodhue County:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Knox silt loam.....	211,200	43.0	Carrington fine sandy loam...	4,672	1.0
Wabash silt loam.....	19,648	9.2	Miami loamy sand.....	4,224	.9
Colluvial phase.....	25,344		Miami fine sandy loam.....	4,160	.9
Marshall silt loam.....	36,864	7.5	Meadow.....	3,136	.6
Carrington silt loam.....	32,448	6.6	Wabash loam.....	2,112	.4
Fargo silt loam.....	24,640	5.0	Wabash fine sandy loam....	2,048	.4
Rough stony land.....	23,552	4.8	Knox fine sandy loam.....	2,048	.4
Carrington loam.....	21,504	4.4	Waukesha loamy sand.....	1,600	.3
Miami silt loam.....	16,768	4.2	Sogn clay loam.....	1,472	.3
Gravel hill phase.....	4,032		Waukesha gravelly sandy loam.....	1,088	.2
Waukesha silty clay loam....	15,360	3.1	Wabash gravelly sandy loam..	960	.2
Carrington silty clay loam....	13,696	2.8	Plainfield silt loam.....	256	.1
Waukesha fine sandy loam....	7,552	1.5			
Waukesha loam.....	5,312	1.1			
Red Wing loamy sand.....	5,184	1.1	Total.....	490,880	

KNOX SERIES.

The Knox series includes types of loessial origin with brown surface soils, underlain by friable brown subsoils. The series is developed on upland areas in the Central Prairie States.

KNOX SILT LOAM.

The Knox silt loam consists of a reddish-brown to dark-brown silt loam, with a depth of 8 to 12 inches, underlain by yellowish-brown to brown silt loam. Both soil and subsoil have a rather open, friable structure, a condition favorable to the ready downward percolation of rain water and its retention for crop use. The type is locally known as "clay" land.

Some areas show variation from the description given above. In places there is an increase in the content of very fine sand, and in some cases the material in such areas becomes more sandy with depth. Another variation is found in a series of knolls, including a belt of territory running southeast from Vasa Township into Belvidere Township. These areas have a gravelly sandy material at depths of 1 to 3 feet below the surface, and small areas of surface exposure of this material are found. The areas in which these variations exist are too small to map consistently, and they have therefore been included in the Knox silt loam.

The Knox silt loam occupies about one-half of the upland of Goodhue County and is located mostly in the eastern part of the county. The surface of the areas in the northern and northeastern part of the county is rolling and hilly, and of that portion occupying the broader and more level drainage divides of the central, western, and southern parts gently rolling.

Most of the type is cleared and in cultivation, only some of the steeper slopes being found in native forest cover. Among the trees noted were oak; elm, ash, maple, box elder, and hackberry. Near the bluff scarps cherry, basswood, and mulberry were seen. Among the vegetation of smaller growth are sumac, hazelnut, and dogwood, wild plum, wild gooseberry, the red raspberry, wild grape, and wild currant.

The Knox silt loam is an extensive type in the county and is held in high esteem, both on account of its natural productiveness and the fine quality of its products. It has in many cases been cropped continuously to small grain and corn and the yields have been seriously reduced. As a consequence, careful management over a number of years is required to bring the land to a high state of productiveness. This soil does better under adverse climatic conditions than the other upland soils. It can be handled within comparatively wide limits in moisture condition, and does not clod readily.

The farms on this type in most cases contain from 80 to 200 acres, and as a rule show a disproportionate acreage of small grain and corn as compared with clover or grass. While this condition exists it will be impossible to practice a well-balanced crop rotation.

The yields of the principal field crops, named in the order of their acreage, are: Barley, 20 to 30 bushels; oats, 25 to 40 bushels; wheat, 15 to 25 bushels; corn, 25 to 40 bushels; rye, 10 to 20 bushels; and clover, 1½ to 2 tons per acre.

The value and importance of red clover for forage and as a soil builder are appreciated, and indications now point to a greater use of this valuable crop. Some alfalfa is being grown on the type.

The improvements and equipment of most of the farms in the Knox silt loam areas are excellent.

Land of this type is held at \$75 to \$100 an acre.

KNOX FINE SANDY LOAM.¹

The surface soil of the Knox fine sandy loam consists of 12 to 18 inches of brown to dark grayish brown heavy fine sandy loam, often differing but little from a light silt loam, underlain by a somewhat more compact yellowish-brown fine sandy loam. Variations of the type occur in which the soil and subsoil contain considerable silt, while in other instances local areas having a somewhat more sandy texture than usual are included.

The Knox fine sandy loam is not very extensively developed in this county, covering only 3.2 square miles. The surface is rolling to hilly, and the drainage is rather excessive. In exposed fields more or less drifting of the fine sand occurs during high winds.

The type seems to be derived in part from the weathering of sandstone and in part from the accumulation of sandstone débris by wind, with some mixture of silty material. As a soil, aside from its origin, it does not differ very much from the Miami fine sandy loam.

The native vegetation of the Knox fine sandy loam is about the same as that of the Knox silt loam, and it is adapted to the same crops.

MARSHALL SERIES.

The Marshall series is an important group of soils in the upland prairie region of the Central West. The soils, like the Knox soils, are derived from loess, but are distinguished from the latter by a higher content of organic matter, and consequently a darker color. The surface soils range from dark brown to black; the subsoil is yellowish brown and sometimes gray and mottled.

MARSHALL SILT LOAM.

The Marshall silt loam consists of a dark-brown to grayish-black silt loam, 10 to 24 inches deep, underlain by a yellowish-brown to mottled gray silty clay.

The type as mapped includes some areas that vary somewhat from this typical description. In places a gray loamy surface soil, with a somewhat fine sandy open subsoil is found, and in others both the surface soil and subsoil are slightly heavier than the average. Extending from Vasa Township into Belvidere Township there is a series of knolls in which there is a gravelly sandy material at a depth of 2 to 3 feet. In places this material is exposed, but such areas were too small to be mapped separately.

¹ A sample of this type shows 8.26 per cent of lime (CaCO_3).

The surface of the Marshall silt loam varies from gently rolling to moderately hilly, and as a rule the drainage is free, though seldom excessive. Little damage is done by erosion. In steep areas gullies sometimes form and it is necessary to take steps to prevent their extension.

The native vegetation includes wild grasses, several varieties of wild vetch, and other leguminous plants. There is practically no native forest cover and the type is locally known as "prairie" land.

The Marshall silt loam is one of the extensive and valuable upland soil types of the county and is largely in cultivation. The size of farms, the relative acreage of the different crops and other conditions are much the same as on the Knox silt loam.

The range of conditions under which this soil may be cultivated is not quite so wide as in the case of the Knox silt loam. If plowed when too wet clods form that are slow to weather to a friable condition. Owing to a somewhat more compact subsoil, this soil is also somewhat less retentive of moisture than the Knox silt loam.

The yields of the principal crops, in the order of their importance, are as follows: Barley, 20 to 30 bushels; oats, 25 to 40 bushels; wheat, 15 to 25 bushels; corn, 25 to 40 bushels; and clover, $1\frac{1}{2}$ to 2 tons per acre.

The farm buildings, machinery, and work horses on the Marshall silt loam are of high class.

Farms on this type are held at \$75 to \$100 an acre.

CARRINGTON SERIES.

The Carrington series includes types derived from glacial till and having black soils and light-brown to yellowish subsoils. The series is developed in the prairies of the Western States and consists mainly of prairie soils.

CARRINGTON SILT LOAM.

The Carrington silt loam consists of dark grayish brown to black silt loam, 12 to 18 inches deep, underlain by a yellow to yellowish-brown, rather compact silt loam to clay loam. Both surface soil and subsoil contain more or less sharp sand and small gravel, with occasional large bowlders. These coarse constituents are usually present in greater quantities in the lower part of the profile.

This type is quite extensively developed in the southern and western parts of the county, where the Kansan glacial drift is exposed, and owes its origin to the weathering of these deposits. On drainage divides the surface varies from level to moderately rolling, rather steep slopes being found along the valleys. The drainage is as a rule adequate, though some local flat areas need ditching to afford sufficient drainage in wet seasons.

The Carrington silt loam is a part of what is locally known as "prairie" land, though at one time it supported a scattering growth of trees and shrubs. Wild grasses, wild vetch, and other legumes are found on the native sod. Most of the type, however, is cleared and in cultivation. It is one of the valuable upland soils of the county.

The farm buildings and other improvements as a rule are good.

Lands of this type are valued at \$75 to \$100 an acre.

CARRINGTON SILTY CLAY LOAM.

The Carrington silty clay loam consists of a dark grayish brown to black silty clay loam, with a depth of 12 to 24 inches, underlain by a yellow to mottled gray clay or clay loam. The gray mottling increases with depth. At a depth of 2 or 3 feet this material rests on stony gravelly till. In the rolling and better drained areas the subsoil is more uniformly yellow in color. Scattered bowlders occur on the surface and more or less throughout both soil and subsoil. Some local areas of silt loam texture are included in the type as mapped.

The Carrington silty clay loam is found in the southwestern part of the county. The surface is gently to moderately rolling and the drainage is adequate except in a few relatively flat areas that need ditching to remove the excess water during unusually wet periods.

The Carrington silty clay loam is a part of what is locally known as "prairie" land, the native cover consisting of wild grasses and several varieties of wild vetch.

Most of the type is in cultivation, and, like the other upland soils, it is apparently well adapted to the production of the general farm crops. Excessive cropping to small grains has reduced its productiveness somewhat.

The farm buildings and other improvements, and the equipment on this type are excellent. The value of the land ranges from about \$75 to \$100 an acre.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Carrington silty clay loam:

Mechanical analyses of Carrington silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
320609.....	Soil.....	0.1	1.1	1.2	2.1	4.3	89.7	21.2
320610.....	Subsoil.....	1.4	4.4	5.0	9.7	12.7	45.2	21.5

CARRINGTON LOAM.

The Carrington loam consists of a dark-gray to black loam, 12 to 18 inches deep, underlain by a yellowish-brown, compact loam. Both soil and subsoil contain relatively high contents of silt and clay

and some gravel. Boulders are scattered on the surface and more or less throughout the soil and subsoil, their number increasing with depth.

The type is found in the western part of the county. It is not extensive. The topography is gently rolling to hilly, and drainage as a rule is good.

The Carrington loam includes a part of the area locally known as "prairie" land, and supports a native vegetation of prairie grass and wild vetches.

Nearly all of the type is in cultivation, being well suited to the production of the general farm crops common to the region. As in the case of the other soil types of this series, however, the continued cropping to small grain and corn has reduced the yields to some extent. Fine farm buildings, farm machinery, and excellent work horses are found on many of the farms of this type. The value of this land ranges from about \$75 to \$100 an acre.

In the following table the results of mechanical analyses of samples of the soil and subsoil of this type are given:

Mechanical analyses of Carrington loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
320617.....	Soil.....	0.2	2.4	3.4	7.0	6.1	58.9	21.6
320618.....	Subsoil.....	1.8	5.4	6.0	14.3	13.0	32.9	26.3

CARRINGTON FINE SANDY LOAM.

The Carrington fine sandy loam consists of a brown to dark-brown sandy loam, 12 to 18 inches deep, underlain by a subsoil consisting of a yellowish-brown, more or less compact silt loam, which becomes more sandy and gravelly with depth. The sand in the soil and subsoil is sharp and gives a gritty feel. Locally the texture ranges from loam on the one hand to sandy loam on the other. Some boulders are scattered on the surface and through the soil and subsoil, the number becoming greater with depth.

Small areas of this soil lie in the upland in the northwestern part of the county. The surface is gently rolling to hilly, and the drainage as a rule ample, though not excessive.

The native vegetation includes a scattering growth of scrub oak, but consists mainly of prairie grass and vetches.

The Carrington fine sandy loam forms a part of the area locally known as "prairie," and is now largely under cultivation. It gives good yields of the field crops. Continuous cropping to small grain and corn has reduced the yields somewhat. The improvements and general appearance of the farms indicate a prosperous condition of agriculture.

The land values on this type range from about \$60 to \$100 an acre.

Results of mechanical analyses of samples of the soil and subsoil of the Carrington fine sandy loam are given in the following table:

Mechanical analyses of Carrington fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
320621.....	Soil.....	0.9	5.9	10.9	23.4	7.4	36.6	14.6
320622.....	Subsoil.....	1.0	5.2	11.0	28.4	11.8	28.8	13.6

MIAMI SERIES.

The Miami series includes types derived in the main from glacial till of a calcareous nature, having brown, light-brown, or grayish surface soils and brown or mottled brown and gray subsoils. The series is found in the glacial region from the Ohio River westward.

MIAMI SILT LOAM.

The Miami silt loam consists of a grayish-brown to dark-brown silt loam, 12 to 15 inches deep, underlain by a pale-yellow to mottled gray silty clay loam, which extends to a depth of about 36 inches or more. A gravelly sandy material is encountered somewhere in the substratum, and a few gravel and bowlders are scattered throughout both soil and subsoil.

The type is quite extensively developed in the southern part of the county.

A part of the Miami silt loam supports a growth of scrub oak, prairie grasses, and wild vetches. Most of it is in cultivation and seems well adapted to the production of the staple crops common to the region.

The surface varies from undulating to rolling. The drainage conditions are satisfactory. The type is fairly resistant to drought.

The Miami silt loam includes lands held at about \$60 to \$100 an acre.

Miami silt loam, gravel hill phase.—There is a series of high knolls and ridges south, southwest and west of Zumbrota and southeast of Vasa, covered to a depth of 1 to 3 feet with silt loam material not unlike that described above, but formed below to great depths of sandy gravelly material, which is in part cross-bedded. These knolls have been mapped as the gravel hill phase of the Miami silt loam.

Most of the phase having the thicker deposit of silt overlying the gravel is in cultivation, and some of the more gravelly areas, by heavy manuring, are made to produce fair yields of field crops.

MIAMI FINE SANDY LOAM.

The Miami fine sandy loam consists of a grayish-brown to dark grayish brown fine sandy loam or loamy sand, 12 to 15 inches deep, underlain by a yellow to mottled gray, more or less compact fine sandy loam. This material, at a depth of $2\frac{1}{2}$ to 3 feet, rests on a sandy gravelly till of considerable depth. The type includes some gravelly knolls and ridges that are quite sandy, and some areas where the stratum of fine sandy and silty material is much thicker than 3 feet. A few boulders are scattered on the surface and through the subsoil.

The principal area of the type is located east of Cannon Falls, and a few scattering areas elsewhere in the western part of the county. A hilly topography is characteristic of this type. The natural drainage is well established, and in dry seasons the type is more or less subject to drought.

Portions of the Miami fine sandy loam have a forest cover consisting of oak, maple, white birch, basswood, hazel brush, wild plum, and wild cherry, with a varied undergrowth. Much of the type is in cultivation and the staple crops yield moderately well. Rye, perhaps, yields best of the small grains, as it matures before the dry season. When well manured the soil is fairly well adapted to certain vegetable crops. Squash and pumpkins do especially well.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Miami fine sandy loam:

Mechanical analyses of Miami fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
320635.....	Soil.....	0.3	3.4	8.4	38.2	8.9	29.7	11.0
320636.....	Subsoil.....	.6	5.1	11.0	43.3	11.0	18.8	10.4

MIAMI LOAMY SAND.

The Miami loamy sand consists of a light-brown to gray fine sand, with varying proportions of silt. This material extends to a depth of 3 feet or more, and rests on a sandy gravelly substratum. In some places the surface soil has a rather open sandy texture, and drifts in exposed places, while in others a rather heavy fine sand or loamy sand is found. The type may best be characterized as a loamy sand.

The Miami loamy sand is developed to a small extent in the vicinity of Cannon Falls, along the Cannon and Little Cannon Rivers. It occupies high terraces, but in some cases the material seems to have been derived as a colluvial rather than as alluvial outwash

from the adjacent soft St. Peter sandstone, underlying the Trenton limestone.

The surface of this type varies from gently rolling to fairly hilly, the latter in a few places only. The drainage is excessive, except in rather wet seasons.

The forest cover consists largely of bur oak, unforested areas having a thin stand of wild grass and sand vetch. Some of the heavier areas are cleared and in cultivation, giving rather small yields of the staple crops. Winter rye seems more certain than other grain crops, probably on account of its early maturity.

Land of this type ranges in value from \$5 to \$25 an acre.

Mechanical analyses of samples of the soil and subsoil of the Miami loamy sand are given in the following table:

Mechanical analyses of Miami loamy sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
320645.....	Soil.....	0.2	6.7	15.3	51.6	17.5	5.8	2.5
320646.....	Subsoil.....	.4	7.3	16.0	52.4	17.2	4.2	2.2

SOGN SERIES.

The Sogn series includes gray soils with gray sticky subsoils, the latter residual from nodular argillaceous limestone. The series occurs in the glacial region where erosion has brought the parent rock close to the surface. The soil proper probably contains some glacial material.

SOGN CLAY LOAM.

The Sogn clay loam consists of a grayish-brown to black clay loam, 6 to 15 inches deep, underlain by a gray to mottled yellow sticky clay. If the soil is plowed when wet, hard clods are formed that are slow to weather. Fragments of limestone and shale are scattered over the surface and are mingled to some extent through the soil and subsoil. They become more abundant with depth, and in some instances the massive rock is encountered at depths of 3 to 5 feet. A few glacial boulders are scattered over the surface.

Small areas of the Sogn clay loam lie from 2 to 4 miles south of Cannon Falls. The surface varies from moderately level to hilly, the latter condition predominating. The areas are well drained.

A forest growth is found on the steeper hilly slopes. It includes oak, ash, basswood, elm, wild plum, wild cherry, poplar, birch, hazel, and other bushy growths. The more level areas are cleared and in cultivation.

The Sogn clay loam is fairly well adapted to the staple crops of the region, though in poor physical condition as a result of continuous

cereal production. Some alfalfa seen on the type seemed to be doing well.

Land of this type is valued at \$60 to \$100 an acre.

RED WING SERIES.

The Red Wing series includes colluvial types lying at the foot of valley walls or spread out over valley slopes in the glacial region where sandstones and limestones outcrop. The soils are brown to dark brown, and the subsoils brown to light brown. The materials come mainly from the rocks mentioned, but contain some wash from glacial and loessial deposits. The series is found in the North Central States.

RED WING LOAMY SAND.

The Red Wing loamy sand is a type that includes a great many local variations, from almost pure fine sand to fine sand carrying much silt. The variations grade so rapidly from one to another that separate mapping was deemed impossible on the scale used, and the type is thus characterized as a loamy sand or loamy fine sand. The color varies from reddish brown to reddish black.

This type is developed to a limited extent south of Red Wing, in the vicinity of Cannon Falls, and in other parts of the county.

It is derived in part from the weathering of the underlying soft St. Croix sandstone near Red Wing and the St. Peter sandstone in the vicinity of Cannon Falls, combined with colluvial wash from the adjacent upland silt loam soils. The uneven mixture gives rise to the local variations noted above. This material may have been modified some by the high water levels obtaining during the fluvio-glacial period, when the high gravel terraces were formed, though the type as a whole lies at a slightly higher level than the true glacial river terraces.

The topographic features of the Red Wing loamy sand range from rather steep colluvial valley slopes to moderately rolling outwash areas. Surface drainage is free, and parts of the type are droughty.

The native vegetation includes oak, ash, maple, white birch, wild plum, wild cherry, hazel brush, raspberries, gooseberries, and other brushy growths.

Much of the type is in cultivation. Fair yields of the staple crops are obtained in good seasons. Winter rye is probably the surest of the field crops, as it matures by the last of June or early in July, and thus escapes the occasional droughty conditions of late summer. Near Red Wing much of the type is planted to small fruits, such as raspberries and strawberries, and used also in the production of green corn, lettuce, radishes, onions, garden peas, potatoes, squashes, pumpkins, watermelons, and cantaloupes. The produce is sold at local markets at Red Wing and Cannon Falls, very little being shipped out of the county.

PLAINFIELD SERIES.

The Plainfield soils are derived from glacial outwash and valley filling deposits. The surface soils are grayish yellow to brown and the subsoils yellow to pale yellow. Soils of this series have been mapped in the North Central States.

PLAINFIELD SILT LOAM.

The Plainfield silt loam consists of a light-gray to dark-gray silt loam, 10 to 15 inches deep, underlain by yellow to gray silt loam, which in turn rests on a gravelly sandy stratum of great depth. The surface soil and subsoil both include local variations in which more or less fine sand may be present. In the main the texture is that of a heavy loam or silt loam.

The type is developed to a limited extent west of Wanamingo. A level to slightly rolling topography is characteristic. Drainage is free and in dry seasons the soil is inclined to be droughty.

The original forest consisted of oak, ash, maple, basswood, and white birch. Most of the type is now in cultivation. Fair yields of the staple crops are obtained in seasons of normal rainfall. Like all the terrace soils underlain by a substratum of gravel and sand early maturing grain crops are deemed the safest to grow. Rye is the best of the cereals under the existing conditions. The type may also be used for small fruits and truck crops where markets are near.

WAUKESHA SERIES.

The types in the Waukesha series are characterized by dark-brown to black surface soils and yellow subsoils. The soils of this series have been derived from water-assorted glacial débris deposited in broad filled-in valleys or as outwash plains and terraces. Types of this description are encountered in the glacial portion of the Central Western States.

WAUKESHA SILTY CLAY LOAM.

The Waukesha silty clay loam consists of a dark-brown to black silt loam, with a depth of 8 to 16 inches, underlain by a brown colored compact silt loam. At depths of 2 to 10 feet the material invariably passes into an open stratified gravelly sandy substratum of great thickness.

The type is quite extensively developed along the North Fork Zumbro, Cannon, and Mississippi Rivers. It occupies two well-defined high river terrace levels, varying from 30 to 100 feet above the present stream levels. The surface varies from level to moderately rolling, and the drainage, owing to the thick, gravelly substratum, is ample to excessive.

Most of the type is in cultivation. In good seasons fair yields of the staple crops are secured. Owing to the tendency to drought, rye is rather the more dependable small grain, as it matures as a rule before the dry summer season comes on. The dairy industry is highly developed on some portions of the type.

Land of this type ranges in value from \$50 to \$75 an acre.

The following table gives the average results of mechanical analyses of samples of the soil and subsoil of the Waukesha silty clay loam:

Mechanical analyses of Waukesha silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
320601, 320623.	Soil.....	0.9	3.9	2.8	4.5	6.9	57.5	23.1
320602, 320624.	Subsoil.....	1.2	3.9	3.3	6.9	11.8	50.1	22.4

WAUKESHA LOAM.

The Waukesha loam consists of a dark-brown to black loam, 12 to 15 inches deep, underlain by a brown to gray compact sandy loam subsoil. At depths varying from 2 to 10 feet a sandy gravelly substratum of great depth exists. The surface soil in some cases includes considerable small gravel. Some of the slightly lower flat areas have a high organic-matter content.

The Waukesha loam is a moderately extensive soil lying on the high terraces along the Cannon and Mississippi Rivers. The surface varies from level to moderately rolling. Drainage is thorough, and owing to the gravelly substratum is likely to be excessive.

Most of the Waukesha loam is in cultivation. Fair yields of the staple crops are obtained in seasons of normal rainfall. In dry seasons the yields are curtailed by drought. Rye, which matures as a rule before the dry periods of summer, is surer than later maturing crops. Small fruits and truck crops are grown to supply the local demand.

Improved land on this type is held at \$50 to \$75 an acre. Some areas near towns are rated considerably higher in value.

WAUKESHA GRAVELLY SANDY LOAM.

The Waukesha gravelly sandy loam consists of a dark-brown to grayish-black gravelly sandy loam, with a depth of 6 to 10 inches, underlain by a lighter colored gravelly sandy subsoil resting on a bed of gray stratified gravelly material of great depth. In a few small areas the soil is sufficiently free of gravel to be classed as a sandy loam, and in others the finer grades of material are present in large enough quantity to give approximately a loam texture. These

variations are not important enough to warrant mapping as separate types.

The Waukesha gravelly sandy loam occupies high river terraces along the Cannon River about 3 miles west of Cannon Falls.

The surface is level to moderately rolling. Drainage is excessive and the type droughty.

Rye yields fairly well in seasons of abundant rainfall.

The type has a relatively low agricultural value.

WAUKESHA FINE SANDY LOAM.

The Waukesha fine sandy loam consists of a brown to dark-brown fine sandy loam, 8 to 16 inches deep, underlain to a depth of about 3 feet by a lighter colored, more or less compact fine sandy loam. The surface soil is somewhat variable in texture, ranging from a sand to loam. It also shows some variation in organic-matter content and hence in color, but in the main the type is a dark-colored fine sandy loam.

The Waukesha fine sandy loam occupies two well-defined terrace levels along the Cannon and Mississippi Rivers. The surface ranges from level to rolling. The drainage is ample and in dry seasons excessive.

The type is in part covered with a forest growth of ash, oak, elm, white birch, box elder, and wild plum. Most of it, however, is in cultivation and produces fair yields of the staple crops in seasons of normal rainfall. The type is underlain by a substratum of gravelly sand, and this makes it somewhat droughty. This soil appears to be fairly well adapted to small fruits and truck crops, which are grown for local use.

Improved farms of this type are held at prices ranging from \$50 to \$75 an acre.

WAUKESHA LOAMY SAND.

The Waukesha loamy sand consists of a gray to black loamy sand, 15 to 24 inches deep, underlain by gray to brown, open loamy sand. The surface material when dry appears gray to light brown in color, but when wet the color is dark brown to black. There seems to be considerable organic matter in the surface soil, but this becomes less apparent with depth. There are local variations in which the soil is a rather heavy loamy sand and others in which it is of a rather open, loose, sandy character, with some pebbles and gravel. The substratum to a great depth consists of the usual terrace stratified layers of sand and gravel.

The Waukesha loamy sand occurs on what is locally known as "Prairie Island," north of Eggleston. It occupies the higher level of the island, some 30 to 50 feet above the general level of the Mississippi River.

The type has a level to rolling surface. Drainage is excessive and the land is inclined to be droughty even in seasons of normal rainfall.

This soil is largely used for growing rye and corn. Rye matures as a rule before the July drought begins. Dry springs, however, sometimes result in very low yields. Ordinarily from 15 to 25 bushels of rye and from 20 to 40 bushels of corn per acre are obtained. Truck crops are grown for home use and produce fair yields when the rainfall is sufficient. Clover does not maintain itself well on the type, it is said.

Land values of the Waukesha loamy sand range from about \$20 to \$50 an acre.

Mechanical analyses of samples of the soil and subsoil of this type follow:

Mechanical analyses of Waukesha loamy sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
320641.....	Soil.....	1.6	25.0	28.5	30.3	4.0	5.6	4.7
320642.....	Subsoil.....	.1	5.6	15.5	43.7	9.8	5.2	19.9

FARGO SERIES.

The types classified in the Fargo series are for the most part derived from lake-laid deposits, though, locally, materials that have washed into moist depressions have been included. The soils are black and the subsoils dark colored and calcareous. Soils of this series have been encountered so far mainly in Minnesota and the Dakotas.

FARGO SILT LOAM.

The Fargo silt loam consists of 12 to 24 inches of a black silt loam to silty clay loam, carrying a large amount of organic matter. The subsoil consists of dark mottled gray sticky clay to a depth of 3 feet or more, resting on a substratum of sandy gravelly material of the Kansan till.

In some areas of the type large glacial boulders are found on the surface. Black, wet, mucky areas are also included. These differ from the remainder of the type mainly in drainage conditions. Such areas are indicated on the map by swamp symbols.

The type occupies narrow, shallow draws and drainage channels in the southern and southwestern part of the county, where the gradient is slight and where seepage water from the adjoining slopes tends to keep the soil excessively moist the greater part of the season.

With the exception of a few willows, the type is treeless. Coarse swamp grasses are the characteristic vegetation. Owing to its wet and poorly drained condition the soil is not under cultivation. It is

used in part for pasturage land, and to some extent for cutting wild hay.

Below are given the results of mechanical analyses of samples of the soil and subsoil of the Fargo silt loam:

Mechanical analyses of Fargo silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
320611.....	Soil.....	0.0	0.3	1.0	4.2	5.6	74.8	13.9
320612.....	Subsoil.....	.0	.4	.4	1.5	8.5	72.1	17.2

WABASH SERIES.

The Wabash series includes soils of alluvial origin lying along rivers of central United States. The types have dark-brown to black soils and somewhat lighter gray to brownish-gray subsoils. In Goodhue County a greater proportion of the deposits is of silt loam texture than is usually the case. This is due to the slow current in the Mississippi and tributary streams, which has been brought about by the obstructions in the Mississippi at the mouth of Chippe-wha River and the formation of Lake Pepin. The same condition has resulted in keeping more of the Wabash areas in a continuously saturated condition than is found where the flood plains lie at a greater height above the normal water level.

WABASH SILT LOAM.

The Wabash silt loam consists of a dark grayish brown to black silt loam, with a depth of 10 to 20 inches, underlain by a black to gray silt loam. The surface soil includes variations consisting of a rather heavy silt loam on the one hand and of a rather open loamy structure on the other, the latter often having a high organic-matter content. Included wet swampy areas are indicated by swamp symbols.

The type is quite extensively developed throughout the county, occupying the bottom-land levels of nearly all the larger and smaller streams and draws. The surface varies from flat to moderately undulating. The surface level above streams varies from about 2 to 10 feet, and natural drainage is good as a rule, except in a few low, flat areas, where ditching or tiling is necessary. The type is more or less subject to overflow during any material rise of streams, and during heavy rains the wash from adjoining valley slopes is sometimes enough to cover it for a short time.

Some areas of the Wabash silt loam are well covered with ash, soft maple, basswood, walnut, willow, box elder, cottonwood, and other bushy growths, while the vegetation of the wet areas consists mainly

of willow and swamp-grass. Such are used largely for pasture land and the production of hay.

Much of the higher lying portion is under cultivation. Corn and rye yield well as a rule. Rye is quite extensively grown on these higher bottom lands and the colluvial slopes. The higher, better drained areas of this type are held at \$20 to \$100 an acre.

Wabash silt loam, colluvial phase.—Along the lower slopes of most of the valleys and the greater part of some of the smaller streams and draws a semialluvial or colluvial condition is extensively developed, which it was deemed best to include as a colluvial phase of the Wabash silt loam. Areas of this character within the glacial drift zone were found to be more or less moist from seepage water, giving in some cases a rather swampy, mucky character to the phase as well as to the adjacent true bottom. Occasional boulders also were found in such areas. The areas below the level of the massive rock strata are not as a rule so wet with seepage as those above. This phase owes its origin to colluvial wash from the silty soils of the upland.

WABASH LOAM.

The Wabash loam consists of a dark grayish brown to black loam, 12 to 18 inches deep, underlain by a black to mottled gray silt loam. The surface soil varies somewhat, areas existing where the soil is rather open and sandy in texture and others where it is heavier and contains more silt.

Relatively small areas of this soil are mapped. These lie along the lower river bottoms. The surface is level to gently undulating and the drainage is ample, as a rule, when the streams are at their normal level. Like its related type, the Wabash silt loam, it is more or less subject to overflow during any general rise of the streams.

The native vegetation and crop adaptation are much the same as noted for the Wabash silt loam.

Improved farms on this type are held at \$60 to \$75 an acre, depending on location

WABASH FINE SANDY LOAM.

The Wabash fine sandy loam consists of a dark-brown to black fine sandy loam, with a depth of 12 to 24 inches, underlain by a black to gray, more or less compact, fine sandy loam subsoil. The organic-matter content as a rule is high. The type includes many local variations, ranging from an open, sandy soil to a rather heavy silty fine sandy loam.

The Wabash fine sandy loam forms a small part of the bottoms of the lower river courses of the county. The topography is level to moderately rolling and drainage conditions good when the streams are normal. The type is more or less subject to overflow, however, during any decided rise in the streams.

The forest cover includes willow, box elder, elm, cottonwood, and various brushy growths. Swamp willow and grasses are found in the lower and swampy areas.

Much of the type is cleared and in wild grass, which is used for pasturage and hay. Some of it is in cultivation, being adapted to the same crops as the other types of this series.

Land of this type ranges in value from \$25 to \$75 an acre.

WABASH GRAVELLY SANDY LOAM.

The Wabash gravelly sandy loam consists of a dark-brown to black gravelly sandy loam, underlain by a black to dark-gray gravelly sandy loam. The surface includes variations in texture from a rather sandy loam with some gravel to a silty gravelly loam high in organic matter.

The type is found to a limited extent along some of the river bottom lands of the county. The surface is level to undulating, and drainage even during seasons of much rainfall is thorough, and excessive on the higher levels in dry seasons. On the other hand, any general rise of the streams overflows much of the land.

A part of the Wabash gravelly sandy loam is covered with elm, oak, ash, basswood, and a brushy undergrowth. Willow and swamp grass are found in the lower areas.

Much of the type is cleared and used for pasture and hay. Some of it is in cultivation, and produces fair yields of rye and corn.

Land of this type ranges in value from \$25 to \$75 an acre.

MISCELLANEOUS MATERIAL.

ROUGH STONY LAND.

The Rough stony land includes the stony cliffs and stony talus slopes along the valleys. The cliffs often stand 50 to 300 feet above the lower valley floors. The type as mapped outlines all the larger and many of the smaller escarpments, and marks very clearly the line of separation of the upland and valley land soils.

The stony talus slopes are usually covered with a forest growth consisting of oak, ash, maple, basswood, hazel brush, wild plum, wild gooseberry, raspberries, and other shrubs, which retard any serious washing from heavy rains. The larger timber growth supplies fence posts, firewood, and other material useful on the farm. These areas afford some woodland pastures. The unforested areas include grass-covered slopes which also give some grazing in the spring. Later in the season the pasturage is very poor. The type has no agricultural value except as noted.

MEADOW.

Meadow includes some of the low-lying overflow lands along the Mississippi River and is of small extent in this county. Some parts of the type consist of a mucky sandy material partly submerged or very little above the level of normal flows of the rivers. Such areas are covered with coarse swamp grasses and a scattered growth of willow and other brushy growths. These during part of the season may be used for pasture for cattle, but not for horses. Other areas, having a silty to fine sandy texture and lying 1 or 2 feet above the normal flow of the river, support a growth of swamp grass and some trees, such as willow and cottonwood. While subject to overflow during flood stages of the river, these higher lying areas of the type may be used during much of the season for pasturage and for cutting wild hay.

Lands of the Meadow type are held at about \$1 an acre for the lower areas and somewhat more for the higher levels.

SUMMARY.

Goodhue County, Minn., is one of the southeastern group of counties lying in the Mississippi River Valley region. The area of the county is 767 square miles, or 490,880 acres.

The county consists of rolling to hilly upland, with an elevation of about 1,000 feet in the eastern part, rising gradually to nearly 1,200 feet in its western part. The drainage is eastward into the Mississippi River. Goodhue County was organized in 1853. According to the last census, it had a population of 31,637, or a little over 40 persons per square mile. Red Wing, the county seat, is the largest town in the county, with a population of 9,048.

Railway and country road transportation facilities are good.

About half the area of the county consists of cultivated fields, the remainder including areas of water, rough stony bluffs, overflow lands, valley forest lands, and permanent pasture lands.

There are 3,080 farms of an average size of 152 acres, 68 per cent of which are operated by their owners, the remainder by tenants.

The average length of growing season is 134 days. The mean annual rainfall is 30 inches. The summer days are long and as a rule hot.

The principal field crops of the county, naming them in the order of their acreages are: Barley, oats, wheat, corn, rye, and hay. Of these, barley occupies 36.71 per cent of the field crop acreage, the first four crops collectively occupying 86.3 per cent. Fruits and truck crops do well, but are generally produced in limited quantities only for home use.

An excessive acreage in small grain and too little in clover has so reduced the producing power of the naturally strong soils of Goodhue County that only about \$1 an acre net profit is realized from field crops. Under a reorganized cropping practice, such as that outlined by the Minnesota Experiment Station and referred to in the chapter on agriculture of this report, net profits of \$3 to \$6 an acre might be expected, without much, if any, more expense per acre than is now expended for labor, equipment, and interest on investment.

The dairying industry has increased in importance decidedly in the last 10 years. Many silos have been constructed and a considerable part of the corn crop is used to fill them. Goodhue County has 13 creameries and 20 cheese factories, which during 1912 paid their patrons \$778,630.26.

Farm laborers receive \$25 to \$35 a month and board. During the rush of grain harvesting \$2 to \$3 a day is paid day laborers, with board.

The better grades of farm land are held at \$75 to \$100 an acre. Inferior land, including low, swampy, gravelly, or stony areas, bring from \$1 to \$50 an acre.

The soils of Goodhue County consist mainly of dark-brown to black silt loams, with relatively small areas of stony, gravelly soils. The soils group naturally into three broad topographic levels, namely, upland, high river terraces, and overflow bottom lands.

Including Rough stony land and Meadow, 25 soil types were mapped. These are grouped into 10 soil series and 2 miscellaneous types.

In the upland are found soils of the Carrington, Miami, Sogn, and Red Wing series. These soils are used largely for the production of the general farm crops. The Knox silt loam, covering 43 per cent of the area of the county, is the most important upland type.

On the river terraces occur soils of the Plainfield and Waukesha series. These soils are used for about the same crops as the upland types, but are more likely to suffer from drought, and rye is a surer crop than the other cereals. Of this group the Waukesha silty clay loam is most extensive.

The bottom lands are formed of soils of the Fargo and Wabash series and Meadow. The Wabash soils are by far the more extensive of the bottom-land types. The better drained areas are used for corn, rye, and the other field crops; the wetter areas for wild hay and pasture land.

[PUBLIC RESOLUTION—No. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

"That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the Congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture."

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

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